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# A longitudinal investigation of cognitive functioning and its relationship to symptom severity and academic functioning in treatment seeking youth with ADHD

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## Abstract

**Background:** Children with ADHD tend to present with poorer cognitive functioning leaving them more vulnerable to a range of negative outcomes. To date, only a handful of longitudinal studies have examined the stability of Wechsler composite scores in children and adolescents with ADHD, and none of them used a more recent version of the Wechsler Intelligence Scales for Children (WISC), than the WISC-III.
**Objective:** The present study investigates the cognitive stability and its longitudinal relationship with the severity of the child's ADHD symptoms and school grades.
**Method:** Cognitive functioning was measured with the fourth editions of the WISC-IV or the Wechsler Adult Intelligence Scales (WAIS-IV) at baseline and at a 3-4-year follow-up in children with ADHD (n = 125, mean age = 11.40 years, SD = 3.27) and a Control group of schoolchildren (n = 59, mean age = 11.97 years, SD = 2.15). The stability of cognitive functioning and the relationship between cognitive functioning, ADHD and grades were evaluated using linear mixed models and logistic regression.
**Results**: Standardized composite scores of Full scale IQ, Verbal Comprehension, and Processing Speed declined between baseline and follow-up in the ADHD group. ADHD symptom scores were associated with Working Memory scores. Together, the severity of concurrent ADHD symptoms and lower scores for verbal comprehension at baseline and follow-up were associated with an increased risk of not achieving grades at follow-up in youth with ADHD.
**Conclusions:** Youth with ADHD often present with cognitive impairments, not improved over time. Together these increase the risk of poorer academic outcomes. Concurrent evaluation of symptom severity and cognitive functions can add potentially useful information in terms of treatment planning, and school supports to prevent school failure.

**Keywords:** ADHD; children; cognitive functioning; follow-up study; WISC; school grades

## Introduction

Attention deficit hyperactivity disorder (ADHD) is a commonly occurring psychiatric disorder associated with poor psychiatric, social, educational, and occupational outcomes across the age-range (1). ADHD is a highly heritable condition (2, 3) but higher levels of intelligence may act as a protective factor for developing ADHD (4). Among the factors associated with poor outcomes in ADHD is the individual's general mental or cognitive abilities as indexed by the Full Scale IQ (FSIQ) score from standardized tests of intelligence (5-7). This is important because meta-analytic studies routinely find that individuals with ADHD, across the age range, present with significantly lower FSIQ scores than control groups (8). However, while lower FSIQ scores are associated with poorer functional outcomes, they do not appear to predict the persistence or remittance of ADHD symptoms over the long-term (9-13). The relationship between

ADHD, IQ and functional outcomes is further complicated by population-based studies that find that FSIQ scores are less stable during childhood for all children (14-16). While there is evidence suggesting that active symptoms of psychiatric disorder may interfere with cognitive functioning during childhood, longitudinal studies tracking both intelligence and psychiatric symptoms are needed (17).

To date, only a handful of longitudinal studies have examined the stability of FSIQ scores in children and adolescents with ADHD. Five studies involving comparison groups have found that (prorated) FSIQ scores tend to be stable at the group level for youth with ADHD. However, these studies employed earlier versions of the Wechsler intelligence scales. This is relevant because subtests and scoring procedures are updated with each new version (18), which may impact interpretations about the stability of the FSIQ and other indices of cognitive functioning in youth with ADHD (19).

Two studies followed youth with ADHD and non-clinical controls using the Wechsler Intelligence Scale for Children (WISC)-III (20) and found that the FSIQ and composite scores were largely stable at the group level over time (11, 21). The more recent study also investigated individual change and found that both FSIQ and other composite scores were largely stable at both the group and individual level, and the composites were not associated with the persistence or severity of ADHD into adulthood (11). To date, one study has examined the stability of WISC-IV (22) composite scores in referred youth with learning disorders with or without attention deficits (23). Composite scores were largely stable at the group but not at the individual level. Longitudinal studies are needed that examine the stability of cognitive functioning from the latest versions of the WISC and Wechsler Adult Intelligence Scale (WAIS), in youth with ADHD. Moreover, such studies should examine the relationship between the severity of ADHD symptoms and functional outcome at each assessed interval. Furthermore, to our knowledge, no study has investigated the association between school grades, the WISC-IV composite scores, and ADHD symptoms at each time point.

In the present study, we examined the long-term outcome of the five composites of the WISC-IV and the WAIS-IV (24) in a group of clinically referred children with ADHD with no known intellectual disability as well as in a control group of the same age. In the ADHD group, the long-term outcome of ADHD symptoms measured with the SNAP-IV and their relationship with Wechsler composites and school grades were investigated. *First*, and based on the evidence available, we hypothesized that FSIQ (i.e. standardized composite scores, based on comparison to same-aged peers) would be stable at the group level between the baseline and the follow-up assessment in the ADHD group. Based on the limited evidence available, Verbal Comprehension, Perceptual Reasoning, Working Memory, Processing Speed (i.e. standardized index scores, based on comparison to same-aged peers) would be stable between measuring points. *Second*, we anticipated that the Wechsler composite scores and the severity of ADHD symptoms at the baseline and follow-up assessments would be unrelated based on previous studies finding that neither FSIQ nor the four composites were associated with ADHD remittance or persistence (11). In reference to findings that both ADHD diagnosis and IQ predict educational outcome (1, 7), we anticipated that ADHD symptom scores and all the Wechsler composite scores at both time points would be associated with school grades.

## Methods

### *Participants*

Youth with ADHD were recruited from consecutive diagnostic assessments at the Neuropsychiatric Unit of the Child and Adolescent Psychiatry (CAP) Clinic in Lund, Sweden; controls were youth of the same age recruited from schools in the same region as the CAP. The inclusion criteria for this longitudinal study were a DSM-IV diagnosis of ADHD (25), fluency in Swedish, and the absence of a DSM-IV diagnosis of mental retardation (25), hereafter referred to as intellectual disability. Individuals with specific learning difficulties (assessed by their school) were not excluded. In the present study, only children assessed with the WISC-IV or the WAIS-IV at baseline were included, resulting in a sample size of N = 184 (ADHD = 125: male = 87, female = 38; Controls = 59: male =31, female = 28). Written informed consent was obtained from all participants (and their parents). This study was approved by the Research Ethics Committee at Lund University, Lund, Sweden (Reg. No. 2012/88), and registered in ClinicalTrials.gov Protocol Registration and Result System (ID: NCT04201509, protocol ID: 2012/88).

## Measures

### *Five to Fifteen*

Five to Fifteen (FTF) (26) is a parent- and teacher-completed screen for development-related impairments and behavioral problems in children and adolescents. The instrument consists of 181 items on a three-point scale (0 = Does not apply, 1 = Applies sometimes/ to some extent, and 2 = Applies), comprising 8 main domains: Motor skills, Executive functions, Perception, Memory function, Language, Learning ability, Social skills, and Emotional difficulties / behavioral problems, all of which have further subdomains. We used scores on the parent-report FTF at baseline to describe the additional impairments of the ADHD group. Scores on the Acting Out and Internalized subdomains (98th percentile cut-off) of the Emotional difficulties / behavioral problems domain were used as controlling variables in the analysis of predictors of academic outcome in the ADHD group. The FTF has acceptable psychometric properties and evidence of clinical validity (27).

***The Swanson-Nolan-Pelham scale, version IV***

The Swanson-Nolan-Pelham scale, version IV (SNAP-IV), is a DSM-IV-based ADHD rating scale for parents and teachers (28, 29). The version of the SNAP-IV used here is comprised of the 18 diagnostic criteria of DSM-IV ADHD, supplemented with eight statements concerning ODD symptoms and four supplementary statements regarding ODD and ADHD. Each item is rated on a 4-point scale (0 = not all; 3 = very much), with higher scores indicating greater frequency/severity. Sum scores (continuous values) from the parent ratings of the SNAP-IV (ADHD-combined score) subscales are analysed in this study (referred to as SNAP-IV). The SNAP-IV has acceptable psychometric properties and evidence of clinical validity (28, 29). The current study used parent ratings of the SNAP-IV (ADHD-combined score) at the baseline and at the follow-up as independent variables.

***Wechsler Intelligence Scales***

Cognitive functioning was measured with the WISC-IV (30) and for youth 16 years or above with the WAIS-IV (31). The WISC-IV and the WAIS-IV consist of ten core battery subtests, yielding four composites. The WISC-IV composites (subtests) are: Verbal Comprehension (Similarities, Vocabulary, Comprehension); Perceptual Reasoning (Block Design, Picture Concepts, Matrix Reasoning); Working Memory (Digit Span, Letter–Number Sequencing); Processing Speed (Coding, Symbol Search); General Ability Index (GAI) and FSIQ. The composites for the WAIS-IV are the same as for the WISC-IV, but the WAIS-IV composites replace some of the subtests: Verbal Comprehension replaces Comprehension with Information; Perceptual Reasoning replaces Pictures Concepts with Puzzles; and Working Memory replaces Letter–Number Sequencing with Arithmetic (32). All composite scores on the WISC-IV and WAIS-IV are standardized according to age, with a mean of 100 and standard deviation (SD) of 15 (32, 33). As the WISC-IV and WAIS-IV use the same indexes but not the same core subtests, Verbal Comprehension, Perceptual Reasoning, Working Memory, Processing Speed, and FSIQ are used as outcome variables to test our hypothesis.

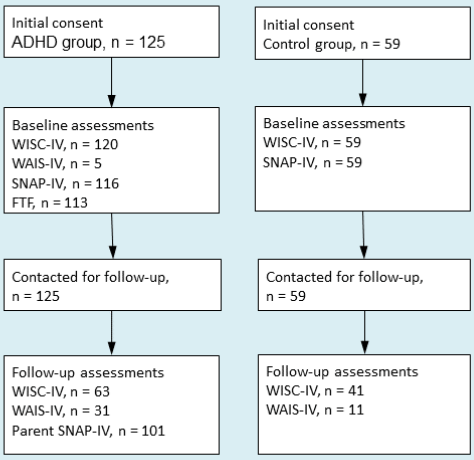


**FIGURE 1.** Flow-chart

ADHD = attention deficit hyperactivity disorder; FTF = Five To Fifteen; SNAP-IV = Swanson-Nolan-Pelham scale, version IV; WAIS-IV = Wechsler Adult Intelligence Scales, fourth edition; WISC-IV = Wechsler Intelligence Scales for Children, fourth edition

## Procedure

### *Baseline assessments*

Figure 1 presents the workflow of the baseline and follow-up assessments. For the ADHD participants recruited from the CAP clinic, all diagnostic assessments were carried out by child and adolescent psychiatrists. An ADHD diagnosis was made based on the DSM-IV criteria (25) using information from multiple sources, including: comprehensive psychiatric interview with the child and their parents (including the SNAP-IV and FTF); semi-structured telephone interviews with teachers; and neuropsychological assessments using the WISC-IV/WAIS-IV (n = 120/5, depending on age) carried out by a psychologist. For most ADHD participants, the neuropsychological assessments were carried out by the referring school psychologists prior to the child's assessment at the CAP clinic. All ADHD participants were medicine-naïve at the baseline assessment.

No formal diagnostic assessments were carried out with the participants in the Control group. As part of the written informed consent procedure, parents of controls completed the SNAP-IV and answered written questions about their educational level. WISC-IV assessments were carried out by experienced clinical psychologists with a specialization in neuropsychology, or by a supervised clinical psychology student trained to use these scales (WISC-IV) in a quiet room at the participant's school.

### *Follow-up assessments*

After the child was assessed and diagnosed with ADHD at baseline, all parents attended a psychoeducation program for parents of youth with ADHD, and most of the ADHD participants were started on an approved stimulant medication (81%). Approximately 3-4 years after the baseline assessment, participants in the ADHD and Control groups were invited for reassessment involving either the WISC-IV or WAIS-IV (n = 63/31 in the ADHD group, and 41/11 in the Control group), the SNAP-IV (parent version), and a written form comprised of dichotomous questions about their current status with respect to medication use, support from school, and school grades. In the ADHD group the parents also answered the question about special educational supports, and 80 parents and seven youths answered the question about grades. In the Control group, the youth answered the questions about grades and special educational supports. All ADHD participants were asked to stop taking any ADHD medication 24 hours prior to the follow-up assessment. The ADHD group were followed-up at the CAP clinic and the Control group in a quiet room at their school or at the CAP clinic. For both groups, the WISC-IV/WAIS-IV assessments were carried out by fully qualified neuropsychologists or supervised clinical psychology students trained to administer these scales.

## Statistical analyses

Between group comparisons, differences between composites and logistic regression analyses were carried out using version 25 of SPSS (IBM Corp., Armonk, NY, USA). Linear mixed model regression analyses were carried out using version 9.4 of SAS (SAS Institute Inc., Cary, NC, USA). Between-group comparisons (ADHD vs Control group; completers vs dropouts) were analyzed with Chi-Square and Student's Independent *t*-tests. Linear mixed models with an autoregressive covariance structure were used to analyze change over time for the standardized composite scores between baseline and follow-up in the ADHD and control groups, as well as the difference between the slopes for the two groups, after controlling for the use of WAIS-IV in relation to WISC-IV. An interaction term between group and time was included to compare change over time for the two groups. Because of the impact of the attrition concerning the Wechsler composite scores, estimated and adjusted mean scores from the linear mixed models were used when comparing the mean scores between the two groups. Linear mixed models with an autoregressive covariance structure were also used in separate analyses of the dependent variables (i.e. the Wechsler composite scores at baseline and follow-up) with several independent variables. For the ADHD group, the independent variables were time (follow-up time in years), gender, use of the WAIS-IV versus WISC-IV, receipt of special educational supports, parental rating of ADHD symptom severity (SNAP-IV ADHD-combined score), and treatment with ADHD medication. For the Control group, the same independent variables were evaluated with the exception of parental ratings from the SNAP-IV and treatment with ADHD medication at follow-up. Unstandardized betas with corresponding 95% confidence intervals and p-values are reported.

Logistic regression models were used to identify ADHD symptom severity (SNAP-IV ADHD-Combined Score) and cognitive functioning (Wechsler scales) at either baseline or follow-up predicted school grades (dependent variable) at follow-up in the ADHD group (only). School grades was a dichotomized variable reflecting whether the participant had either a simple majority of passing grades or a simple majority of failing grades at follow-up. The predictor variables were added in two models, one with baseline scores from the SNAP-IV (ADHD-combined score) and Wechsler composite scores, and the other with the follow-up scores on these same measures. A number of controlling variables (assessed at baseline) were entered in each model: sex (being female); receiving special educational supports; assessment via the WAIS-IV (vs WISC-IV); parents' education level; and scores on the Externalizing and Internalizing subdomains from the parent-rated FTF. Odds ratios with corresponding 95% CI's and p-values are reported.

## Results

### *Sociodemographic characteristics and attrition*

Of the 125 participants in the ADHD group at baseline, 87 (70%) were boys compared to 31 of 59 (52%) participants in the Control group ($\chi^2(1) = 5.1$, $p = .024$). The gender ratio at the follow-up assessment was similar but with no significant differences. The two groups did not differ for age at baseline (ADHD = 11.40 (SD = 3.27), Controls = 11.97 (SD = 2.15)) or at follow-up (ADHD = 15.13 (SD = 2.98); Controls = 14.80 (SD = 2.03)). The two groups did not differ at baseline for parents' level of education: primary school only (to age 16): ADHD = 11%, Controls = 4%; high school (age 16-19 years): ADHD = 46%, Controls = 35%; university or above: ADHD = 43%, Controls = 61% ($\chi^2(2) = 5.3$, $p = .071$). At follow-up, the ADHD and Control groups significantly differed with respect to the proportion of participants receiving special educational supports (ADHD = 59%, Controls = 23%; $\chi^2(1) = 17.70$, $p = .001$) and receiving a simple majority of passing grades (ADHD = 61%, Controls = 100%; $\chi^2(1) = 19.92$; $p = .001$).

There was no difference in the attrition rate between baseline and follow-up with 103/125 (82.4%) of the ADHD and 52/59 (88.1%) of the Control participants completing the baseline and follow-up assessments. However, ADHD participants lost to follow-up performed significantly worse than those who completed the follow-up assessment on the FSIQ (mean difference ($M_{diff}$) = 8.54; $t(123) = 3{,}39$; $p = 0.001$; 95% CI: 3.55, 13.52)), Verbal Comprehension ($M_{diff} = 7.57$; $t(123) = 2{,}81$; $p = 0.006$;95% CI: 2.23,12.90), and Perceptual Reasoning ($M_{diff} = 7.89$; $t(123) = 2{,}79$; $p = 0.006$; 95% CI: 2.29, 13.50). There were no significant differences between completers and non-completers of the follow-up assessments in the Control group for any of the IQ measures/composites. Table 1 presents the means and standard deviations for the Wechsler composite scores (FSIQ, Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed), parent-rated SNAP-IV (ADHD-combined score) at baseline. Table 2 presents descriptive data for parent rated functional impairments at the baseline (FTF).

**TABLE 1.** Means and standard deviations for scores on the Wechsler scales and SNAP-IV for ADHD and Control participants

| | Groups | | | |
|---|---|---|---|---|
| | ADHD | | Controls | |
| Baseline measures | n | Mean (SD) | n | Mean (SD) |
| WISC-IV/WAIS-IV | 120/5 | | 59/0 | |
| FSIQ | 125 | 88.90 (12.67) | 59 | 96.51 (9.71) |
| Verbal comprehension | 125 | 93.43 (13.36) | 59 | 95.12 (12.97) |
| Perceptual reasoning | 125 | 97.06 (14.04) | 59 | 101.41 (12.00) |
| Working memory | 125 | 82.03 (12.95) | 59 | 93.02 (10.45) |
| Processing speed | 124 | 88.69 (13.59) | 59 | 98.42 (11.06) |
| SNAP–IV | 116 | 30.69 (10.58) | 59 | 5.98 (6.81) |

*Notes.* ADHD = attention deficit hyperactivity disorder; FSIQ = full-scale intelligence quotient; SD = standard deviation; SNAP-IV = The Swanson-Nolan-Pelham scale, version IV (ADHD-combined score). The SNAP-IV is measured in summary scores (0-54); the WISC-IV/WAIS-IV composite scores are measured in standardized composite scores, mean = 100, SD = 15

***Stability of Wechsler Scale composite scores***

Figure 2 presents the slopes for the beta values and the 95% CI's for the Wechsler Scale composite scores between baseline and follow-up in the ADHD and Control groups, as well as the difference between the slopes for the two groups, after controlling for whether or not the baseline assessment was conducted using the WAIS-IV instead of the WISC-IV. There was a significant negative effect for group (all *p*'s < 0.001) on the baseline (FSIQ ($M_{diff}$ = −7.54; 95% CI: −11.25, −3.84), Working Memory ($M_{diff}$ = −11.05, 95% CI: -14.68, -7.42), Processing Speed ($M_{diff}$ = −9.68,95% CI: −13.82, −5.55) and follow-up measures (FSIQ ($M_{diff}$ = −12.05; 95% CI: −15.85, −8.24); Verbal Comprehension ($M_{diff}$ = −10.67; 95% CI: −14.95, −6.39); Perceptual Reasoning ($M_{diff}$ = −7.30; 95% CI: −11.63, −2.96); Working Memory ($M_{diff}$ = −8.63; 95% CI; −12.42, −4.83); Processing Speed ($M_{diff}$ = −11.76; 95% CI: −16.06, −7.46)). For ADHD participants, there was a significant and negative effect of time (i.e., a slight decline in scores) on the FSIQ (*p* = .028), Verbal Comprehension (*p* = .007), and Processing Speed (*p* = .040) scales. By way of contrast, a significant and positive effect of time (e.g., a slight increase in scores) on the Verbal Comprehension scale (*p* < .001) in the Control group. The baseline to follow-up slopes for the FSIQ (*p* = .001) and Verbal Comprehension scales differed significantly between the two groups (*p* < .001).

***Associations between the index and composite scores and the severity of ADHD symptoms and other predictors***

Table 3 presents the results of the linear mixed modeling of the relationships between the Wechsler composite scores (dependent variable) and the independent variables (time, sex, use of the WAIS-IV versus WISC-IV, receipt of special educational supports, parental rating of ADHD (combined) symptom severity (SNAP-IV), and when applicable, treatment with ADHD medication for each group. A number of significant relationships emerged for the ADHD group. There was a significant and negative effect of time on FSIQ, Verbal Comprehension, and Processing Speed scores. Over the three-year follow-up, the age standardized FSIQ scores decreased 2.79 points, while Verbal Comprehension scores and Processing Speed scores decreased 2.76 and 4.11 points, respectively. The severity of ADHD (combined) symptoms was negatively associated with Working Memory scores. Use of the WAIS-IV as opposed to the WISC-IV was associated with lower scores on Verbal Comprehension and higher scores on Processing Speed. Female sex was positively associated with Processing Speed. For the Control group, there was a significant and positive effect for time on the FSIQ and Verbal Comprehension scales, and a significant and negative effect for receiving special educational supports on FSIQ and Processing Speed scores.

***Relationship between grades, ADHD symptoms and Wechsler Scale composites in the ADHD group***

Table 4 presents the results of the logistic regression analyses evaluating the relationship between the severity of parent-rated ADHD (combined) symptoms (SNAP-IV) and Wechsler composite scores at baseline and follow-up, and whether the child received a majority of passing grades (yes/no) at the follow-up, for the ADHD group only. The model with predictors assessed at baseline (SNAP-IV and Wechsler composite scores) was not significant. However, Verbal Comprehension at baseline was a significant predictor of having a majority of passing grades at follow-up. The model with predictors assessed at follow-up (SNAP-IV and Wechsler composite scores) was statistically significant, with an explanatory effect of 36%. Verbal Comprehension scores assessed at follow-up were associated with a significantly higher likelihood of receiving a simple majority of passing grades at follow-up. An increase of one standard deviation (15 points) on the Verbal Comprehension scale increased the odds ratio of this outcome by 4.53 times. Less severe ADHD (combined) symptoms (SNAP-IV) were also significantly associated with an increased likelihood of achieving a simple majority of passing grades at follow-up. A decrease of 10 parent-rated summary scores on the SNAP-IV increased the odds ratio of this outcome 2.30 times. The results did not differ significantly when we controlled for confounders.

**Discussion**

The current study examined the long-term stability of the five composite scales of the WISC-IV and the WAIS-IV and their relationship to ADHD symptoms and school grades in a group of treatment-seeking youth with ADHD and a control group of the same age. Contrary to expectation, WISC-IV/WAIS-IV standardized composite scores were not stable for the ADHD participants, with FSIQ, Verbal Comprehension, and Processing Speed all declining between baseline and follow-up. Consistent with expectation, Wechsler composite scores, except for Working Memory, and ADHD symptom severity at baseline and follow-up were unrelated (Figure 2, Table 3).

Before proceeding, it is important to note that this study was carried out with a sample of youth who were clinically referred and received treatment for ADHD in specialist child and adolescent psychiatry services. Youth with intellectual disability were

**TABLE 2**. Descriptive clinical data of parent-rated comorbid symptoms at the baseline in the ADHD group

| | Percentiles | | | | | |
|---|---|---|---|---|---|---|
| **FTF variables** | **< 90** | | **≥ 90 < 98** | | **≥ 98** | |
| | n | % | n | % | n | % |
| Motor skills | 67 | 60 | 35 | 31 | 10 | 9 |
| EF | 14 | 12 | 62 | 55 | 36 | 32 |
| Perception | 46 | 41 | 51 | 46 | 15 | 13 |
| Memory | 39 | 35 | 58 | 51 | 16 | 14 |
| Language | 54 | 48 | 40 | 35 | 19 | 17 |
| Learning | 25 | 26 | 39 | 41 | 32 | 33 |
| Social skills | 38 | 34 | 56 | 50 | 19 | 17 |
| Externalized | 27 | 24 | 39 | 34 | 47 | 42 |
| Internalized | 59 | 52 | 38 | 34 | 16 | 14 |
| Compulsivity | 71 | 57 | 34 | 27 | 8 | 6 |

*Notes.* ADHD = attention deficit hyperactivity disorder; ES = executive functions; FTF = Five to Fifteen questionnaire

**TABLE 3.** Results for the predictors in relation to long-term outcomes for each of the Wechsler composites in separate linear mixed model analyses.

| **Dependent variable** | **Independent variables** | **Groups** | | | | | |
|---|---|---|---|---|---|---|---|
| | | ADHD T1, n = 90, T2, n = 93 | | | Controls T1, n = 59, T2, n = 52 | | |
| | | Beta [a] | 95% CI | *p*–value | Beta [a] | 95% CI | *p*–value |
| FSIQ | Time (year) | −.93 | −1.51 ;−.35 | .002 | 1.10 | .41 ; 1.79 | .002 |
| | Girls vs boys | 4.10 | −1.05 ; 9.25 | .117 | −1.37 | −6.65 ; 3.91 | .605 |
| | WAIS vs WISC | 3.11 | −.86 ; 7.07 | .119 | −.71 | −5.34 ; 3.92 | .740 |
| | Special education supports | −.95 | −5.80 ; 3.89 | .696 | −9.25 | −16.49 ; −2.02 | .013 |
| | SNAP IV T1, T2 [b] | −.08 | −.23 ; .06 | .250 | −.04 | −.54 ; .45 | .861 |
| | ADHD medication | 1.55 | −4.47 ; 7.56 | .611 | | | |
| Verbal comprehension | Time (year) | −.92 | −1.58 ;−.26 | .007 | 2.13 | 1.19 ; 3.06 | <.001 |
| | Girls vs boys | 4.39 | −1.35 ; 10.12 | .132 | −3.75 | −10.27 ; 2.77 | .253 |
| | WAIS vs WISC | −5.79 | −10.31 ;−1.27 | .014 | −2.59 | −8.78 ; 3.60 | .374 |
| | Special education supports | −3.26 | −8.65 ; 2.13 | .232 | −6.71 | −15.65 ; 2.22 | .137 |
| | SNAP IV T1, T2 [b] | −.02 | −.18 ; .15 | .821 | .14 | −.47 ; .75 | .654 |
| | ADHD medication | .50 | −6.20 ; 7.19 | .884 | | | |
| Perceptual reasoning | Time (year) | −.43 | −1.07 ; .21 | .184 | .88 | −.19 ; 1.94 | .104 |
| | Girls vs boys | 1.73 | −4.21 ; 7.68 | .564 | −5.61 | −12.20 ; .98 | .093 |
| | WAIS vs WISC | .98 | −3.43 ; 5.38 | .653 | −2.48 | −9.45 ; 4.49 | .446 |
| | Special education supports | .29 | −5.87 ; 5.30 | .919 | −7.45 | −16.48 ; 1.58 | .104 |
| | SNAP IV T1, T2 [b] | .07 | −.09 ; .23 | .390 | .02 | −.60 ; .64 | .954 |
| | ADHD medication | 1.94 | −5.00 ; 8.89 | .579 | | | |
| Working memory | Time (year) | −.28 | −1.06 ; .50 | .484 | −.52 | −1.45 ; .41 | .268 |
| | Girls vs boys | .77 | −3.95 ; 5.49 | .746 | 4.78 | .45 ; 9.11 | .031 |
| | WAIS vs WISC | 5.35 | .30 ; 10.40 | .039 | 3.59 | −2.22 ; 9.40 | .198 |
| | Special education supports | −.48 | −4.92 ; 3.95 | .830 | −4.06 | −10.01 ; 1.88 | .176 |
| | SNAP IV T1, T2 [b] | −.23 | −.41 ; −.06 | .009 | −.23 | −.64 ;.17 | .252 |
| | ADHD medication | −.79 | −6.28 ; 4.70 | .775 | | | |
| Processing speed | Time (year) | −1.37 | −2.21 ; −.53 | .002 | .30 | −.86 ; 1.47 | .602 |
| | Girls vs boys | 6.19 | .70 ; 11.68 | .028 | 3.36 | −2.17 ; 8.89 | .228 |
| | WAIS vs WISC | 10.51 | 4.98 ; 16.04 | .001 | .09 | −7.18 ; 7.37 | .978 |
| | Special education supports | 3.02 | −2.14 ; 8.18 | .248 | −9.52 | −17.11 ; −1.94 | .015 |
| | SNAP IV T1, T2 [b] | −.12 | −.32 ; .07 | .212 | −.16 | −.68 ; .36 | .538 |
| | ADHD medication | 2.91 | −3.48 ; 9.30 | .369 | | | |

*Notes.* ADHD = attention deficit hyperactivity disorder; 95% CI = 95% confidence interval; df = degrees of freedom; FSIQ = full scale intelligence quotient; SD = standard deviation; SNAP−IV = parent rated Swanson−Nolan−Pelham scale, version IV (ADHD-combined score); T1 = time 1 (baseline); T2 = time 2 (follow−up).
a Beta values are unstandardized; b SNAP−IV was measured at T1 and T2 in the ADHD group, and at T1 in the Control group.
The Wechsler composite scores are measured in standardized composite scores, mean = 100, SD = 15

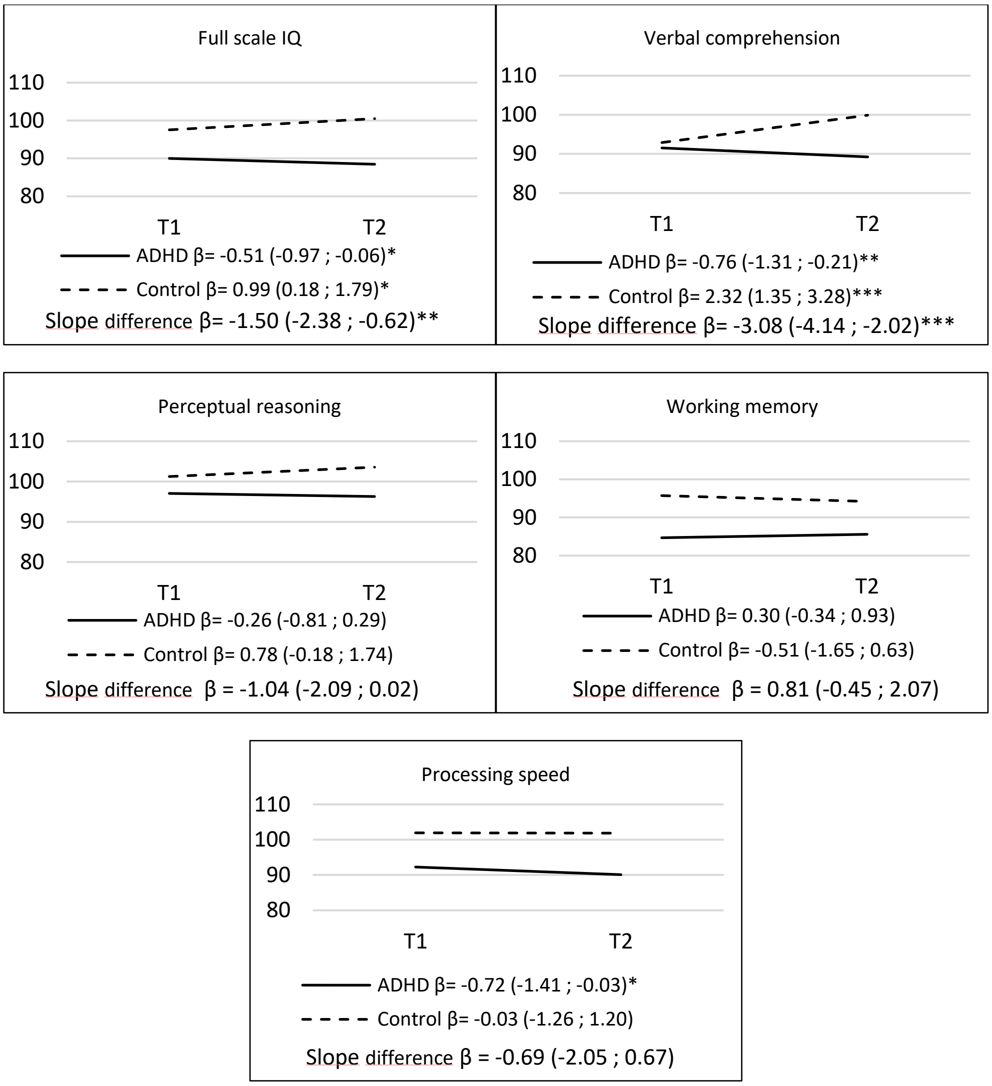


**FIGURE 2**. Linear diagram presenting slopes of the beta values for the Wechsler composite scores for the ADHD and Control groups between baseline and the 3-4 year follow-up and the slope differences.

*Notes.* β = Beta, not standardized. FSIQ = full scale intelligence quotient. In parenthesis 95% confidence interval. The beta values are controlled for Wechsler version used at first and (WISC-IV and WAIS-IV) and second assessment (WISC-IV and WAIS-IV). ADHD group: T1, n = 125, except for Processing Speed, n = 124; T2, n = 94. Control group: T1 n = 59; T2, n = 52; * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

**TABLE 4.** Results of logistic regression models of the relationship between the dependent variable grades at follow-up, and the independent variables parent rated SNAP-IV scores, and Wechsler composites in the ADHD group

| Model statistics | Variables | Odds Ratio | 95% CI | *p*-value |
|---|---|---|---|---|
| T1 Measures | SNAP-IV T1 | .99 | .94 ; 1.04 | .678 |
| $X^2$ = 5.86 | Verbal comprehension | 1.05 | 1.00 ; 1.10 | .031 |
| df = 5 | Perceptual reasoning | .99 | .96 ; 1.04 | .788 |
| *p* for model = .32 | Working memory | .98 | .94 ; 1.02 | .335 |
| Nagelkerke $R^2$ = .094 | Processing speed | 1.00 | .97 ; 1.04 | .815 |
| n = 82 | | | | |
| T2 Measures | SNAP-IV T2 | .92 | .87 ; .98 | .007 |
| $X^2$ = 23.80 | Verbal comprehension | 1.11 | 1.04 ; 1.19 | .001 |
| df = 5 | Perceptual reasoning | 1.01 | .96 ; 1.07 | .624 |
| *p* for model < .001 | Working memory | .95 | .89 ; 1.00 | .073 |
| Nagelkerke $R^2$ = .356 | Processing speed | 1.00 | .96 ; 1.04 | .897 |
| n = 79 | | | | |

*Notes.* 95% CI = 95% confidence interval; SNAP-IV = The Swanson-Nolan-Pelham scale. version IV (ADHD-combined score); T1 = time 1 (baseline); T2 = time 2 (follow-up) excluded because the present data were obtained as part of a larger study focused on the validity of a continuous performance test (CPT) as a marker of ADHD severity in treatment-seeking youth with a primary diagnosis of ADHD and IQ in the normal range. Individuals with specific learning difficulties were not excluded. Consistent with other studies of clinically referred youth with ADHD, the present sample scored at the higher end on parent-rated measures of ADHD, with additional impairments in motor, executive, perception, memory, language, learning, social and emotional functioning at baseline (Table 2).While the average IQ scores for the ADHD group fell into the normal range (Table1), these were still significantly lower than for controls at baseline (FSIQ, Working Memory, Processing Speed) and follow-up (all composite scales). Participants in the ADHD group were also more likely to be receiving special educational supports and less likely to have achieved a majority of passing grades by the end of the follow-up period, despite receiving treatment (including methylphenidate) between the baseline and follow-up.

Again, contrary to expectation, we observed a small but significant decrease in standardized scores for FSIQ and the Verbal Comprehension and Processing Speed composites in the ADHD group between baseline and follow-up (Figure 2, Table 3). This does not mean that cognitive performance itself decreased; Wechsler IQ and composite scores are based on comparison to same-age peers. By way of contrast, FSIQ and Verbal Comprehension scores in the Control group increased between baseline and follow-up. These results contrast somewhat with a previous study by Murray (2017) that found all Wechsler (WISC-III) standardized composite scores to be stable over time in youth with ADHD, at both the group and individual level (11). However, baseline IQ scores in the Murray study were relatively low (mean FSIQ = 86.32-87.70) (11), and thus the stability of IQ over time may have represented a floor effect (34). The differences between the current study and Murray may also be owing to differences in the samples and the use of different versions of the WISC.

The observed declines in FSIQ, Verbal Comprehension and Processing Speed in the ADHD group found in this study should be interpreted with caution until replication studies with similar samples are carried out. Nevertheless, it may be that the observed declines are partly owing to the impact of ADHD symptoms on the children's schooling, and this in turn negatively affected their performance over time on the composite scales. Systematic reviews of the literature find that even among youth receiving methylphenidate for ADHD (as was the case in this study), significant difficulties remain in the child's classroom performance (35, 36); difficulties that may negatively impact acquisition of general knowledge, vocabulary, and graphomotor speed which are assessed by the FSIQ, Verbal Comprehension, and Processing Speed composites. In partial support of such a view, previous studies have found an inverse relationship between impulsivity and measures of intelligence in school children, specifically scales with higher loadings on overall knowledge and vocabulary (i.e., crystallized intelligence) (37). Likewise, there is evidence that children with ADHD have a reduced capacity to improve graphomotor speed and automatization after practice, that may partly explain classroom difficulties (38).

The current study found that the severity of parent-rated ADHD symptoms was associated with a small but significant decrease over time in scores on the Working Memory scales from the WISC-IV and WAIS-IV (Table 3). The longitudinal relationship between indices of executive functioning and ADHD symptom severity remains unclear. Several longitudinal studies have not found any significant associations between executive functions and the course of ADHD symptoms (12, 13, 39, 40), while others have found mixed results (41, 42). Again, differences in sample selection and the measures used to assess ADHD severity and cognitive functioning may partly explain the lack of consistent findings.

Finally, and compared to the Control group, the ADHD group were significantly less likely to achieve a simple majority of passing grades at follow-up. Both Verbal Comprehension (lower) at baseline and follow-up, and the severity of ADHD symptoms at follow-up, predicted a higher risk of this negative outcome (Table 4). The association between scholastic underachievement and ADHD behavior is well known (5, 43-45). However, what is less clear is how intellectual disability across the IQ range interact with ADHD and comorbid problems to effect treatment response and overall functioning, including scholastic achievement. Individuals with intellectual disability were excluded from this study, as is the case in the majority of studies carried out on individuals with ADHD (46). The current study adds further evidence from a small number of studies that suggest that negative educational outcomes in youth with ADHD are likely to reflect both the severity of current symptoms and subtle cognitive deficits (5-7). Thus, while neuropsychological tests may yield little helpful information in trying to make a definitive diagnosis of ADHD, their inclusion alongside other standardized measures, in both clinical and research settings, may further our understanding of overall impairment and influences on the same in individuals with ADHD (46). Similarly, it is widely known that individuals with ADHD often have comorbidity in the form of specific learning difficulties (47). Further research is needed to help separate, to the extent possible, the contribution of specific learning difficulties, IQ, and comorbid psychiatric difficulties to overall functioning in individuals with ADHD.

## Limitations

The results of the current study must be viewed within the context of certain strengths and limitations. The present study benefits from: (1) a longitudinal design employing widely used standardized measures, both parent-rating forms and psychologist-administered neuropsychological tests; (2) low rates of attrition and the use of sophisticated statistical procedures capable of producing models with censored data; and (3) a sample comprised of clinically referred youth with ADHD and comorbid difficulties and an age-matched, non-referred control group. While we controlled for the receipt of special educational supports in our analyses, the present study excluded youth with known intellectual disability, and we did not assess for diagnosis of specific learning disabilities. No standardized structured diagnostic interviews were carried out in the ADHD or control groups, however all diagnoses in the former were validated by experienced psychiatrists working in specialist child and adolescent psychiatry services. Still, it is possible that some youth in the Control group were suffering from a psychiatric disorder, and the Control group had higher percentage of girls than the ADHD group. Finally, using the WAIS-IV, in relation to the WISC-IV, affected the standardized scores negatively in verbal comprehension, and positively concerning Processing Speed, only for the ADHD group. Individuals with ADHD may differ from normative samples concerning different Wechsler versions (19).

## Conclusion

- Contrary to expectation, a small but significant decline was observed over the three-year interval in several standardized composite IQ measures (FSIQ, Verbal Comprehension, Processing Speed) in this clinical sample of youth with ADHD.
- In line with previous studies, standardized Perceptual Reasoning and Working Memory scores were stable over time.
- Long-term measures of ADHD symptom scores were associated with long-term Working Memory scores.
- Poorer educational outcomes at follow-up were associated with lower Verbal Comprehension scores at baseline and follow-up and with the severity of ADHD symptoms at follow-up.

## Clinical implications

Negative educational outcomes in youth with ADHD may arise as a function of the severity of current ADHD symptoms and subtle cognitive deficits. Concurrent evaluation of symptom severity, and cognitive functions can add potentially useful information in terms of treatment planning, and school supports to prevent school failure.

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### Disclosures

No potential conflict of interest was reported by the authors.

### Data availability statement

Non-digital data supporting this study are curated at Child and adolescent psychiatry, Department of Clinical Sciences, Lund, Skåne University Hospital, Lund University, Lund, Sweden.

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

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